UNITED STATES DEPARTMENT OF AGRICULTURE

AGRICULTURAL RESEARCH SERVICE

REPORT OF THE ARS RESEARCH PLANNING CONFERENCE ON WEED AND BRUSH CONTROL AND RELATED INTEGRATED RESEARCH ON RANGELANDS

COLLEGE STATION, TX

FEBRUARY 24-25, 1982

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FOREWORD

Annual losses from weeds and brush on rangeland and cost of control are conservatively estimated at $1.7 billion. Weeds and brush are a problem on well over half of the approximate 630 million acres of rangeland in the United States. Weeds and brush induce losses by decreasing forage production, water yield from watersheds, wildlife habitat, and recreational use. Cost of handling livestock, death and injury losses of livestock, and human allergies are greatly increased by dense stands of poisonous, thorny, or pollen-producing plants. Although poisonous range weeds often infest only a small percentage of a grazing area, they kill livestock and also restrict proper utilization of desirable forage species in the area. Poisonous plants cause an estimated loss of $250 million each year. Weeds also cause failure in establishment of new forage seedings.

A survey in 1965 indicated an estimated 320 million acres of grazing land was infested with brush. This includes 70 million acres of mesquite, 76 million acres of juniper species, and 96 million acres of sagebrush. In addition, many non-woody weeds, including downybrome, larkspurs, thistles, pricklypear, rabbitbrush, spurges, medusahead, bitterweed, and halogeton infest vast areas.

Weed and brush control, regardless of the method used, is an important early step in range improvement. Reestablishment and maintenance of vigorous forage and browse for wildlife and livestock are the immediate and ultimate goals. Maintenance of an aesthetically pleasing landscape and the continued yield of high quality water from watersheds are also important. Reestablishment of vegetation is one of the most difficult tasks in converting range from weeds and brush to desirable forage.

Recognizing that all methods and integration of weed and brush control on rangelands (chemical, biological, mechanical, fire, etc.) are important, special emphasis was also given to forage establishment and maintenance at this Research Planning Conference. The Organizing Work Group for the ARS Research Planning Conference on Weed and Brush Control and Related Integrated Research on Rangelands consisted of R. W. Bovey (Chairman), R. A. Evans, H. L. Morton, L. A. Andres and L. F. Bouse. The committee members express their appreciation to all participants of the conference.

Special thanks is given to E. J. Peters, Columbia, MO; D. L. Linscott, Ithaca, NY; and R. L. Nichols, Tifton, GA for sharing their research results and expertise in forage establishment techniques and to the National Research Program Leaders G. E. Carlson and J. J. Drea, Jr., Beltsville, MD and R. J. Miravalle, PPR Staff, New Orleans, LA for their contributions.

The committee thanks W. C. Shaw, NPS for Weed Science and Agricultural Chemical Technology, for his guidance and counsel during the planning and conduct of the conference.

F O R E W O R D

Annual losses from weeds and brush on rangeland and areas of pasture are conservatively estimated at [illegible] billion. Weeds and brush are a problem on well over half of the approximately [illegible] billion acres of rangeland in the United States. Weeds and brush reduce [illegible] by decreasing forage production, water yield from watersheds, wildlife habitat, and recreational use. [illegible] of handling livestock, death and injury losses of livestock, and [illegible] are greatly increased by dense stands of [illegible], or poisonous plants. Although poisonous range weeds often infest only a small percentage of a grazing area, they kill livestock and also restrict proper utilization of desirable forage species in the area. Poisonous plants cause an estimated loss of $250 million each year. Weed [illegible] is establishment of new forage seedlings.

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Weed and brush control, regardless of the method used, is an important early step in range improvement. Re-establishment and maintenance of desirable forage and browse for wildlife and livestock are the immediate and ultimate goals. Maintenance of an aesthetically pleasing landscape and the continued yield of high quality water from watersheds are also important. Reestablishment of vegetation is one of the most difficult tasks in converting range from weeds and brush to desirable forage.

Recognizing that all methods and integration of weed and brush control on rangeland (chemical, biological, mechanical, fire, etc.) are important, special emphasis was also given to forage establishment and maintenance at this Research Planning Conference. The Organizing Committee for the [illegible] Planning Conference on Weed and Brush Control and Related Integrated Research on Rangelands consisted of R. W. Bovey (Chairman), [illegible] Evans, [illegible], [illegible] Hodges and [illegible]. The committee members express their appreciation to all participants of the conference.

Special thanks is given to [illegible], Columbia, [illegible]; [illegible], Ithaca, NY; and [illegible], Tifton, GA for sharing their [illegible] and expertise in forage establishment techniques and [illegible] Program Leaders [illegible] and [illegible], Beltsville, MD and [illegible], NPS Staff, New Orleans, LA for their contribution.

The committee thanks [illegible], NPS for [illegible] for his guidance and counsel during the planning and [illegible] the conference.

SUMMARY OF THE ARS RESEARCH PLANNING CONFERENCE ON WEED AND BRUSH CONTROL AND RELATED INTEGRATED RESEARCH ON RANGELANDS

Twenty-five ARS and state scientists met in College Station, Texas on February 24 and 25, 1982 to plan national and location research priorities on weed and brush control on rangeland and related integrated practices. Three National Research Program Leaders attended the conference including Drs. Shaw, Carlson and Drea. The welcome and introductions were given by Dr. Bovey. Dr. Rex Johnston, Area Director (Oklahoma-Texas Area), gave a brief history and significance of grassland research. Dr. Shaw, NRPL for Weed Control and Agricultural Chemicals Technology, outlined the objectives of the conference.

Each researcher gave a short presentation about his research program to bring participants up-to-date and to provide an information base for future planning. Special emphasis was given to forage establishment and maintenance with or after weed or brush control and related practices. Presentations were also given by Dr. Jack Witz, Agricultural Engineer, on the use of computer modeling in research and by Dr. B. J. Ragsdale, Range Management Specialist, on technology transfer from researchers to land managers. A tremendous volume of quality information was presented by the ARS scientists and guest speakers.

On February 25, 1982, national and location research priorities were established by the conference participants. The researchers were asked to submit location research priorities prior to the conference. At the conference all location priorities were rated by each scientist and the data summarized. The location priority lists and summary (presented in detail at the end of this report) was used as a basis for establishing the national research priorities.

The national research priorities were established, ranked and presented in priority sequence as follows:

Priority 1. Study the biology, ecology and edaphic factors as the basis for control technology.

Priority 2. Brush and weed control on grazinglands with special emphasizes on improving desirable vegetation.

Priority 3. Absorption/translocation/metabolism of herbicides in weeds, brush and forage plants.

Priority 4. Economic assessment of weeds and brush control technology.

Priority 5. Develop improved herbicide formulations and delivery systems technology.

Priority 6. Systems technology for vegetation manipulation, management and multiple use objectives.

Priority 7. Foreign exploration and cooperation for biological control agents.

Priority 8. Evaluate multiple use strategies in biological control of weeds and brush.

Priority 9. Develop and use models to improve weed and brush technology.

Priority 10. Livestock grazing management to manipulate and manage weedy rangelands.

Policy Issue: It was also suggested that Special Strike Force Funds be made available to support high priority research when needed to accelerate and complete important technological developments.

The group also unanimously agreed more engineering technology was needed in our programs and every effort should be made to employ engineers to support ARS research and missions.

A current list of SY's and dollar support is summarized for all locations in Table 1. Data are also given for immediate future needs. As indicated, an increase of at least $3,000,000 is needed just to maintain the efficiency of the programs within the next 2 years. In order to make significant progress, a total increase of $4,955,400 is necessary to add new or key scientists, operating funds and equipment at several locations.

The ARS scientists that participated in this conference are highly motivated, enthusiastic and capable researchers who have made significant contributions to the scientific literature and American agriculture (see Section C for some of the latest contributions). The need for their continued and increased support in funds and personnel is paramount.

A summary of current ARS scientists and research programs on weed and brush control and related research on rangelands is presented in Section A.

Participants in the USDA-ARS Research Planning Conference on Weed and Brush Control on Rangelands and Related Integrated Research on Rangelands

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February 24 & 25, 1982

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A. Summary of ARS Weed Research Programs on Pastures and Rangelands

Research by ARS on weed control on pastures and rangelands is conducted by the following scientists:

L. A. Andres, Research Entomologist
Albany, CA

P. E. Boldt, Research Entomologist
Temple, TX

L. F. Bouse, Agricultural Engineer
College Station, TX

R. W. Bovey, Research Agronomist
College Station, TX

J. B. Carlton, Agricultural Engineer
College Station, TX

J. R. Cox, Range Scientist
Tucson, AZ

E. H. Cronin, Plant Physiologist
Logan, UT

C. J. DeLoach, Entomologist
Temple, TX

R. M. Dixon, Soil Scientist
Tucson, AZ

R. E. Eckert, Jr., Range Scientist
Reno, NV

R. A. Evans, Range Scientist
Reno, NV

R. D. Hagin, Research Agronomist
Ithaca, NY

V. L. Hauser, Agricultural Engineer
Temple, TX

C. H. Herbel, Range Scientist
Las Cruces, NM

T. N. Johnsen, Jr., Research Agronomist
Tucson, AZ

H. B. Johnson, Ecologist
Temple, TX

J. Klisiewicz, Research Plant Pathologist
Albany, CA

D. L. Linscott, Research Agronomist
Ithaca, NY

D. M. Maddox, Research Entomologist
Albany, CA

H. S. Mayeux, Jr., Range Scientist
Temple, TX

M. K. McCarty, Research Agronomist
Lincoln, NE

R. E. Meyer, Plant Physiologist
College Station, TX

H. L. Morton, Plant Physiologist
Tucson, AZ

R. L. Nichols, Research Agronomist
Tifton, GA

R. W. Pemberton, Research Entomologist
Albany, CA

E. J. Peters, Research Agronomist
Columbia, MO

S. S. Rosenthal, Research Entomologist
Albany, CA

H. A. Schreiber, Soil Scientist
Tucson, AZ

M. C. Williams, Plant Physiologist
Logan, UT

J. A. Young, Range Scientist
Reno, NV

A summary of existing ARS research on weed control on pastures and rangelands is given below by location, with listing of scientists and titles and objectives of CRIS Projects as of March 1982.

Ithaca, NY: D. L. Linscott
R. D. Hagin

Title - Develop integrated weed control and limited-tillage systems for forages, pastures and rotations (1307-20280-001)

Objectives: Develop methods of weed control for pasture and forage crop establishment which require a minimum of energy input. Develop field and forage crop rotations and reduced tillage systems using principles and procedures of integrated pest management that result in economic production and resource conservation. Develop methods of weed control and vegetation management which result in minimal

chemical residues and minimal negative effect on the environment. Determine herbicide metabolites, degradation products and modes of degradation in pasture and forage plants and soils. Ascertain the environmental factors and plant characteristics influencing efficacy of herbicides and the physiological effects on weeds and desirable species. Determine the allelopathic effects of weeds on crop species.

D. L. Linscott and R. D. Hagin devote 100% of their research efforts to weed control in cool humid pastures, forage crops and rotations involving forages.

Tifton, GA: R. L. Nichols

Title - Weed control in pastures and forage crops (7702-20281-007)

Objectives: To determine various biological and ecological parameters of selected pasture weed species and how these factors influence weed control programs and to develop weed management programs for the establishment and production of small-seeded legume and grass forages.

R. L. Nichols devotes 100% of his research to weed control in pastures and forage crops.

College Station, TX: L. F. Bouse
J. B. Carlton

Title - Improved delivery systems for aerial application of pest control agents, seed and fertilizer (7302-20301-001)

Objectives: To increase the efficiency, effectiveness and safety of aerial application of chemical and biological materials used in integrated pest management systems and to increase the uniformity of distribution of seed and fertilizer applied by aircraft. Develop technology and methodology for the application of electrostatically-charged sprays from aircraft. Develop a positive metering system for aerial application of pelleted herbicides and seeds. Determine the effect of application parameters on the uniformity of distribution of pelleted herbicides and on the efficacy, efficiency and safety of pesticide sprays applied by aircraft. Develop technology to rapidly measure the deposition of aerially applied sprays.

L. F. Bouse and J. B. Carlton devote 50% of their research to weed and brush control.

College Station, TX: R. W. Bovey
R. E. Meyer

Title - Weed control on pastures and rangeland (7302-20280-002)

Objectives: To develop methods of control for honey mesquite, huisache, live oak, Macartney rose, whitebrush, smutgrass and other weeds on pastures and rangeland by chemical, mechanical and other means and to investigate the physiology, ecology, anatomy, morphology and phenology of the same species under laboratory and field conditions.

R. W. Bovey and R. E. Meyer devote 100% of their research to weed control on pastures and rangeland.

Temple, TX: C. J. DeLoach
P. E. Boldt

Title - Biological control of weeds and brush on rangelands (7307-20260-001)

Objectives: Determine which weeds are most appropriate for biological control and the research approach to be used. Determine the key organisms that currently limit weed growth and density under natural conditions in the U.S. and determine the ecological factors that limit their effectiveness. Determine the type of foreign organism that would best supplement present natural control, and estimate the degree of success an introduced organism would achieve.

Conduct explorations in foreign areas (principally South America) to find promising control agents. Conduct tests in South America (or other countries) to insure the safety and estimate the effectiveness of candidate control agents.

Introduce foreign organisms into quarantine in the U.S. to insure their safety for release.

Release organisms in the field under conditions to insure their establishment and spread throughout the area infested by the weed.

Measure the degree of control achieved, estimate the costs of the program and the benefits derived, determine if additional control agents are needed, and integrate into existing management systems.

Top priority weeds for biological control are snakeweed (Gutierrezia), baccharis (Baccharis), whitebrush (Aloysia), bitterweed (Hymenoxys), mesquite (Prosopis), tarbush (Flourensia), and creosotebush (Larrea).

C. J. DeLoach and P. E. Boldt both devote 100% of their research to biological control of weeds.

Temple, TX: V. L. Hauser

Title - Develop new methods for grass establishment on pasture and rangeland (7307-20110-001)

Objectives: Develop new methods for establishing grass that will substantially increase the probability of successful stand establishment initially. These methods should either avoid or control the rapid drying of the surface soil in which grass seeds are planted. Concepts such as transplants, germinated seed, and punch planting will be developed. The developments should be continued until the required machines are developed to mechanize the new or improved methods.

V. L. Hauser devotes 100% of his time to grass establishment research.

Temple, TX: H. S. Mayeux, Jr.

Title - Biology and control of range weeds and brush (7307-20280-001)

Objectives: Evaluate both conventional and new weed control practices as independent treatments and as components of weed and brush management systems. Develop and evaluate a machine which directly and selectively applies herbicide solutions to undesirable shrubs. Describe the characteristics of epicuticular wax deposits on leaves of species which respond erratically to broadcast sprays, and determine how these barriers influence herbicide effectiveness. Increase our understanding of the biology of range weeds through studies of their reproductive strategy and life history. Determine the fate and persistence of new herbicides after application to grasslands.

H. S. Mayeux, Jr. devotes 100% of his research to weed control on rangelands.

Temple, TX: H. B. Johnson

Title - The ecology of woody and herbaceous range plants in relation to range production and brush management (7307-20280-003)

Objectives: Evaluate the influence of different types of woody plants on the performance (persistence and production) of nonwoody plants in selected range ecosystems. The project will be conducted in three phases: 1) determination of shrub invasion patterns, 2) measuring spheres of influence of individual shrub plants, and 3) developing life history profiles of selected species.

H. B. Johnson devotes 100% of his research to ecological research of woody and herbaceous range plants in relation to range production and brush management.

Columbia, MO: E. J. Peters

Title - Methods of controlling weeds in forages and agronomic crops (3402-20280-003)

Objectives: To develop better methods of applying less herbicide to pastures; to devise methods of establishing grass-legume mixtures in tilled and untilled soil; to explore biological facets of weeds to devise better methods of control; to explore the potential of insects to control weeds.

E. J. Peters devotes 100% of his research to weed control in forages.

Lincoln, NE: M. K. McCarty

Title - Control of weeds on humid pastures and rangelands (3416-20280-002)

Objectives: Evaluate various methods for control of weeds in pasture and rangelands. Determine life cycles of specific weeds and study phenotypic variability among specimens from areas of infestation

across North America. Evaluate insects for control of introduced weeds and role of plant interspecific variability on effectiveness of control. Develop nurseries for study of phenotypic variability of major weed species to help resolve some current taxonomic problems.

M. K. McCarty devotes 100% of his research on weed control on pasture and rangeland.

Las Cruces, NM: C. H. Herbel
D. M. Anderson
R. P. Gibbens
J. M. Tromble

Title - Improving forage production on arid range (5513-20110-002), Grazing studies on arid rangeland (5513-20110-003), Increasing range forage through efficient use of water (5513-20110-004), and Comprehensive study of rehabilitated range ecosystems in the Southwest (5513-20110-005)

Objectives: Evaluate range improvement practices (control of creosotebush, mesquite, and tarbush) and develop revegetation methods for deteriorated ranges. Determine net primary production on range sites and the soil-plant-water-livestock relationships so that effective management systems may be devised. Develop cost effective livestock management systems for arid rangelands through field studies and computer modeling. Determine the value of water harvesting to increase productivity of areas infested with creosotebush. Determine effects of chemical and mechanical control of creosotebush on forage resources.

These four scientists devote about 2.5 SY's to brush control, productivity, and management of arid rangelands of the Southwest.

Tucson, AZ: H. L. Morton

Title - Range weed and brush control (5502-20280-003)

Objectives: Develop principles and practices of rangeland weed and brush control which are effective, safe, economical and cause minimal harm to the environment.

H. L. Morton devotes 90% of his time to rangeland weed and brush control research and 10% to forage plant establishment research.

Tucson, AZ: T. N. Johnsen, Jr.

Title - Integrated weed management for range ecosystems improvement (5502-20280-004)

Objectives: To develop principles of rangeland brush and weed control, in combination with management practices, to improve and/or maintain forage production and protect range sites without harm to the environment. Conduct field, laboratory, and greenhouse studies on ecological, physiological, and agronomic aspects of important southwestern rangeland brush and weed species such as broom snakeweed, tarbush, and burroweed, and their impacts on associated desirable species like grama grasses, lovesgrasses, drop seed and saltbush. Studies are to help develop methods of predicting the impact of range brush and weed control

measures on population dynamics, life histories, and ecological shifts of brush and weeds and their influence on range forage species establishment, productivity, yields, and interspecies competition.

T. N. Johnsen, Jr. devotes 100% of his research to weed control on rangelands.

Tucson, AZ: J. R. Cox

Title - Methods of establishing forage plants on southwestern rangelands (5502-20110-002)

Objectives: Evaluate plants for forage production on southwestern rangelands. Assessment of the effects of seedbed preparation methods on the establishment of forage plants.

J. R. Cox devotes 100% of his time to research on establishment and evaluation of forage plants on southwestern rangelands.

Tucson, AZ: H. A. Schreiber

Title - Nutrient requirement of rangeland plants (5502-20110-003)

Objectives: Determine the mineral nutrient concentrations and efficiencies of rangeland plants and compare their requirements to those of cultivated plants. Evaluate the effects of improved nutrient status on establishment of range plants. Determine the manner, timing, and rate of nutrient uptake in plants as influenced by growth. Ascertain the interactions of mineral nutrition with other range management practices.

H. A. Schreiber devotes 100% of his time to research on nutrient status of plants and how nutrients influence the establishment, competition, productivity and persistence of rangeland plants.

Albany, CA: L. A. Andres
D. M. Maddox
R. W. Pemberton
S. S. Rosenthal
J. Klisiewicz

Title - Insects and plant pathogens as biological agents to control weeds (5209-20260-001)

Objectives: To comprehend the relationship between plants, their environment and their natural enemies and seek ways of using this knowledge in the development of sound, effective weed management programs.

Title - Biological control and management of yellow starthistle and other weed *Centaurea* species (5209-20280-001)

Objectives: To find, study, and utilize host-specific natural enemies for the control of the weedy *Centaurea* spp. in the U.S., as part of a management program to reduce losses from these plants.

L. A. Andres, D. M. Maddox, R. W. Pemberton and S. S. Rosenthal devote 90%, 10%, 100% and 100%, respectively, of their research to insects and plant pathogens as biological agents to control weeds (5209-20260-001). L. A. Andres, D. M. Maddox and J. Klisiewicz devote 10%, 90% and 100%, respectively, to biological control and management of yellow starthistle and other weedy Centaurea species (5209-20280-001).

Reno, NV: R. A. Evans
R. E. Eckert, Jr.
J. A. Young

Title - Weed control and improvement of semi-arid rangelands of western United States (5517-20280-003)

Objectives: Develop methods of herbicidal, cultural and biological control of woody and herbaceous weeds; integrate with seeding of forage and browse species and with different grazing management systems; and evaluate effects in terms of livestock production, watersheds and wildlife on rangelands.

Title - Pilot testing of integrated weed control, seeding, and grazing management on sagebrush grasslands (5517-20280-002)

Objectives: Evaluate operational brush and weed control and seeding technologies on degraded rangelands and integrate these with different grazing management systems. Determine forage and livestock responses and evaluate in terms of ranch/resource economics and effects on wildlife and watershed.

Title - Range improvement of the Western Intermountain Region (5517-20110-001)

Objectives: Determine species trend responses and forage production under different grazing management systems on unimproved rangelands and on rangelands that have been improved by brush and weed control and seeding. Evaluate results in terms of livestock production, ecosystem stability, watershed, wildlife, and ranch/resource economics.

R. A. Evans, R. E. Eckert, Jr, and J. A. Young devote 100% of their research to weed control and range improvement.

Logan, UT: E. H. Cronin

Title - Ecological life cycle and populations dynamics of selected locoweed taxa (5521-20280-003)

Objectives: To determine the factors that influence the various stages of development of locoweeds, their longevity, and population cycles. To determine methods of controlling or predicting dense populations that cause severe economic losses to users of western rangelands.

Title - The ecology and control of poisonous range plants (5521-20280-006)

Objectives: To study the life cycles of poisonous range plants and determine the optimum time and stage of growth to control their populations

with herbicde treatments. To evaluate the impact of grazing on the populations dynamics of poisonous plants before and after applications of control treatments and to develop strategies to reduce livestock losses and increase forage production that are economically advantageous.

E. H. Cronin devotes 100% of his research effort to poisonous plants on rangelands; their ecology, their impact on livestock and livestock management, and methods for economically controlling poisonous plants that will enhance the grazing resource.

Logan, UT: M. C. Williams

Title - Physiology, biochemistry, and toxicology of poisonous range weeds (5521-20280-001)

Objectives: Investigate the biochemistry, physiology, and ecology of poisonous plants; to identify poisonous compounds, and determine their seasonal variation and concentration. Study the chemical structure and distribution of nitro compounds in *Astragalus* and related nitro-bearing genera. Develop chemotaxonomic methods for predicting the presence of nitro and other toxic compounds in plants. Study toxicity of poisonous plants to laboratory and domestic animals. Develop methods of chemical control for poisonous range weeds. Study seed dormancy, life histories, and reproductive processes in poisonous plants.

M. C. Williams devotes 100% of his research to the physiology, biochemistry, and toxicology of poisonous range weeds.

B. Current Resources and Major Research Needs

Estimates of ARS efforts devoted to weed and brush control and related integrated research on rangelands were obtained from (TH) Summary of Funds and SY's, NRP 20280: Weed Control Technology (2/26/82) and from the participating scientists. The total ARS effort in FY 1981 was 30 SY with an expenditure of $3,109,685 (Table 1). Most projects, however, do not have sufficient funds to efficiently do the research and the majority of the scientists indicate a dire need for technical support (Table 1).

Additional financial support indicated for this research group was over $2,500,000 just to maintain present programs at efficient levels (Table 1). In addition to badly needed technical help, additional scientists, equipment, laboratories, greenhouses, shops and specialized facilities including adequate operating funds were indicated.

The needs for the various locations doing research are indicated as follows:

Ithaca, NY: D. L. Linscott
R. D. Hagin

Additional technician and operating budget is needed for existing program. Additional data processing, forage and retrieval equipment is needed. Estimated funds needed to cover increases is $50,000.

Tifton, GA: R. L . Nichols

Develop cost effective weed control systems for increased forage and livestock production.

Funds required: 135,000

Justification: Eighty-five percent of all cattle in the Southeastern United States are raised for beef. Grasslands provide 80% or more of the feed-units these cattle consume. Although reduction of pasture weeds increases forage yields on a weight for weight basis, less than 15% of all Southeastern grazing lands are treated to control weeds. High costs of brush and weed control prohibit producers from managing grazing lands for increased production. Moreover, no effective pasture weed control system is compatible with the maintenance of forage legumes in warm season perennial grass pastures in the Southeast.

Plan of work: The overall program will proceed in three stages: (1) develop new technology to control brush, perennial, and annual weeds, (2) integrate weed control systems with the establishment and management of legumes, (3) evaluate animal performance and the effects of grazing on pastures in forage-livestock systems identified as showing potential for increased production efficiency. This program requires additional support personnel and an interdisciplinary approach including cooperation from animal scientists.

Way in which increase would tie to work already in progress: Work on pasture composition, weed phenology and its relation to control, new herbicides and herbicide synergists, and techniques for the establishment of winter annual forages is already underway. Further development, integration and evaluation of these techniques within the animal production system is required. The proposed research

would provide a framework for evaluating short and long term effects of the management of pasture vegetation on animal performance and botanical stability. The proposed program would coordinate and integrate USDA-ARS and state efforts to increase livestock production by improving pasture composition.

College Station, TX: R. W. Bovey
R. E. Meyer

Develop improved integrated systems for control of weeds and brush on rangelands to increase forage and livestock production.

Funds required - $1,000,000

Justification - Forage production on 90 million out of over 100 million acres of grazing lands in Texas is reduced by at least 50% because of dense populations of weeds and brush. Control of mesquite in the heaviest stands on 25 to 30 million acres has potential to increase beef production by 45%. At current beef prices, increases to ranchers and the economy of Texas could exceed $200 million per year. Control of other brush problems such as cactus and oaks in the Southwest have similar potential. Improved weed control and forage establishment techniques would enable ranchers to significantly increase forage production, quality and quantity of livestock products, wildlife habitat and recreation, watershed yield, soil fertility and stability and agriculture income.

Plan of work - This program will consist of 3 phases including the development of: 1) New weed and brush control technology, 2) Forage establishment and revegetation practices that will aid in weed and brush control and help maintain improved grazing capacity and 3) Forage establishment and livestock grazing systems. For this program the following additional SY's are needed including support personnel and would be located at College Station and Temple, TX: 1) A weed scientist/plant physiologist, 2) A weed scientist/range ecologist, 3) An agricultural engineer, 4) A soil scientist, and 5) A biochemist.

Way in which increase would tie to work already in progress - Several new herbicides show promise for weed and brush control and forage establishment on rangelands. However, a highly concentrated effort utilizing the expertise described herein will be required to develop basic data for large scale and practical techniques for rangeland improvement. The proposed research program will strengthen, accelerate and fill research gaps in current state and USDA-ARS programs and will provide a well-balanced and coordinated program between ARS and TAES scientists at College Station, Temple and other locations involving weed and brush control research and revegetation efforts.

College Station, TX: L. F. Bouse
J. B. Carlton

Funds required - $875,000

Justification - Engineering research on pest control problems in general has declined significantly during the last 15 years. The current ARS Engineering effort on weed and brush control on rangelands is about 1 SY. For this reason the technology for applying herbicides, reducing spray drift hazards, reducing exposure to herbicides, and other engineering related problems concerning brush and weed control have been badly neglected. A concentrated effort to increase engineering input and support for engineering research must be made before significant progress can be achieved in these areas.

An additional 5 SY's (3 engineers, 1 formulation chemist and 1 agricultural meteorologist) with support funds for new and expanded lines of research is needed. Estimated total - $700,000/year. Facilities for research; research machine shop, equipment storage, field laboratory, aircraft hangar expansion and shop equipment is also needed. Estimated total - $175,000.

Temple, TX: C. J. DeLoach

In order of priority:

1) One technician and adequate operational budget for the existing research program (the present 2-SY effort has a total of $111,600 at the project level). An additional $98,400 is needed.

2) Annual funds of $10,000 for travel to South America for exploration for additional natural enemies and to review and coordinate the ongoing research at the ARS Hurlingham, Argentina laboratory.

3) Additional technical support at the Hurlingham, Argentina laboratory. Estimated total needed, $50,000 at the location level.

4) One additional scientist (Research Entomologist) at Temple, TX, with supporting funds for technical help. Estimated need - $105,000. Extramural - $25,000.

5) Additional research scientist (Research Entomologist) at Hurlingham, Argentina. Estimated cost - $150,000.

6) One additional scientist (Research Plant Pathologist) at Temple, with supporting funds for technical help and equipment. Estimated cost - $105,000

Temple, TX: V. L. Hauser

Added funds are needed for short term employees (on an annual basis) to assist with field experiments, $12,000. One new engineer with support money and staff is needed to develop machines for grass establishment, $150,000. A plant physiologist is needed to study the relation of grass seeds, soil, water, and temperature as it affects plant establishment, $150,000.

Temple, TX: H. S. Mayeux, Jr.

A laboratory technician is needed to assist in studies of herbicide uptake and transport in weeds, and to analyze herbicide residue samples. Additional funds needed for operating expenses, travel to study sites, and summer help total $35,000.

Temple, TX: H. B. Johnson

Personnel - An additional technician for analytical laboratory work

Equipment - Soil surface moisture meter (nuclear gauge)

Travel funds - For field work in other parts of Texas and the Southwest

Remote sensing capabilities - Funds needed to develop cooperative projects with those who have the remote sensing tools that can be used to answer questions on brush ecology.

Columbia, MO: E. J. Peters

Additional support is needed to do work on integrated control of perennial herbaceous and woody species. Also, additional greenhouse, headhouse and laboratory space is needed to efficiently carry out the work, $300,000.

Lincoln, NE: M. K. McCarty

Additional support (1 technician) is needed, $25,000.

Las Cruces, NM: C. H. Herbel
D. M. Anderson
R. P. Gibbens
J. M. Tromble

Two additional technicians and adequate operating funds are badly needed for the existing research program. Estimated total needed annually, $90,000.

Tucson, AZ: H. L. Morton

Added funds are needed for purchase of a crawler tractor to be used in mechanical control and forage plant establishment research, $75,000.

Tucson, AZ: T. N. Johnsen, Jr.

Additional funds are needed to purchase environmental monitoring equipment (temperature, humidity, soil moisture, tension, wind, solar radiation), $100,000.

Tucson, AZ: J. R. Cox

An experimental watershed is needed on which control of land, livestock and other resources is maintained by ARS scientists in order to implement integrated pest management systems on a watershed, $400,000.

Tucson, AZ: H. A. Schreiber

Additional funds are needed to purchase additional laboratory analytical equipment, $50,000.

Albany, CA: L. A. Andres
D. M. Maddox
R. W. Pemberton
S. S. Rosenthal
J. Klisiewicz

Long range - 1) Need increased domestic quarantine capability for testing and processing weed-feeding insects. Present quarantine services WR, NCR and NER.

2) Quarantine facility needed for receiving and processing foreign plant pathogen studies on behalf of the WR, NCR and NER are being handled at the USDA-ARS Frederick, MD quarantine.

3) One support professional (physiological plant ecologist) and technician needed to evaluate impact of weed-feeding arthropods and plant pathogens on weeds and to implement their use, $105,000.

Short range - 1) Three additional technicians needed to provide one full time technician per professional scientist. Approximately $25,000/technician/year.

2) Adequate funding to permit foreign travel to collect natural enemies of naturalized weeds and to participate in the release and evaluation of weed natural enemies in the Western Region. Approximately $20-30,000 (plus increased travel ceiling allotment).

3) Funding to allow extramural contracting for specific research studies (i.e. taxonomic study of leafy spurge, development of diets to mass-produce spurge-feeding insects, plant pathogen studies, etc.), $50,000/year.

USDA lab at Rome, Italy (supportive of the domestic range weed biological control program) - 1) Funding for plant pathologist (either USDA scientists to be stationed on site or for extramural studies by European scientists) to search out, identify, and test weed-associated plant pathogens, $120,000/y

2) Operational money to allow employment of foreign scientists on temporary basis (i.e. contract or temporary employees) either at Rome or other advantageous sites (i.e. Greece, Turkey, Rumania, Austria, etc.).

Reno, NV: R. A. Evans

Two additional technicians and one secretary are needed along with some additional funding to support present program. Also, line budget funding is necessary to replace pilot test funding commencing in FY-84. Additional funding for these critical needs will be $120,000 in FY-83 and $250,000 commencing in FY-84.

Logan, UT: E. H. Cronin

A full time technician and an adequate operating budget to employee summer help as well as funds to maintain spraying and sampling equipment operating effectively and current. Estimated total needs - $60,000/ annually.

Logan, UT: M. C. Williams

Additional operating funds for one part-time position throughout the year and one full-time position in the summer, and for purchase of domestic and laboratory animals for toxicology studies. Estimated total needed - $50,000 (Not including salary of scientist).

Table 1. Current ARS Research Effort and Future Needs in Weed and Brush Control

Location	Support FY 82		Future Needs		
	SY's	Dollars	SY's	Support	Addnl Cost/yr
Ithaca, NY					
Weed Control	2	235,845	0	Technician and Data Proc. Equip.	50,000
Tifton, GA					
Weed Control	0.7	98,359	0	Technician, Equipment & Expt. land	135,000
College Station, TX					
Weed Control	2	302,357	5 (Weed Scientist, Range Ecologist, Agric. Engineer, Soil Scientist & Biochemist)	Support personnel & increased operating funds	1,000,000
Pest Control Equip. & Methods Res. Unit	2	183,600	5 (3 Engineers, 1 Form. Chemist & 1 Meteorologist)	Support personnel & increased operating funds	700,000
				Shop, storage, laboratory & hanger expansion	175,000
Temple TX					
Biological Control	2	111,600	3 (Res. Entomologist - Temple, TX Res. Plant Path. - Temple, TX Res. Scientist - Argentina)	Technician & increased operating funds	458,400
				Foreign travel	10,000
				Argentina Laboratory	50,000
				Extramural	25,000
Grass Establishment	1	117,000	2 (Plant Physiologist & Agric. Engineer)	Support personnel & increased operating funds	312,000

Table 1. Current ARS Research Effort and Future Needs in Weed and Brush Control (Cont'd)

Location	Support FY 82		Future Needs		
	SY's	Dollars	SY's	Support	Addnl Cost/yr
Temple, TX (Cont'd)					
Weed Control	1	114,792	0	Technician & increased operating & travel funds	35,000
Ecological Research	1	114,792	0	Technician, equipment & travel funds	35,000
				Remote sensing capability	10,000
Columbia, MO					
Weed Control	1	90,000	1 (Weed Scientist)	Technician & additional green-house & laboratory space	300,000
Lincoln, NE					
Weed Control	0.8	84,254	0	Technician	25,000
Las Cruces, NM					
Range Management	4	260,000	0	2 Technicians & support funds	90,000
Tucson, AZ					
Weed Control	0.9	117,400	0	Tractor	75,000
IWM Systems	1	122,500	0	Environmental monitoring equip.	100,000
Forage Establishment	1.1	123,000	0	Experimental watershed	400,000
Nutrient Status of Plants	1	123,000	0	Analytical laboratory equip.	50,000
Albany, CA					
Biological Control	5	456,400	Long range:		
			1 (Ecologist)	Technician & increased support funds	105,000
				Quarantine capability (domestic), quarantine facility for foreign plant pathogens	unknown

Table 1. Current ARS Research Effort and Future Needs in Weed and Brush Control (Cont'd)

Location	Support FY 82		Future Needs		
	SY's	Dollars	SY's	Support	Cost/yr
Albany, CA (Cont'd)					
Biological Control (Cont'd)			Short range:	3 Technicians	75,000
				Foreign travel funds	30,000
				Extramural research	50,000
Rome, Italy			1 (Plant pathologist)	Increased operating funds	180,000
Reno, NV					
Weed Control	3	329,265	0	2 Technicians, 1 secretary and operating funds	120,000
				Increase for FY 84	250,000
Logan, UT					
Physiology of Poisonous Plants	1	121,309	0	Technician and increased operating funds	50,000
Ecology of Poisonous Plants	1	74,210	0	Technician and part-time help and increased operating funds	60,000
Totals	31.5	3,179,683	18		4,955,400*

* Does not include dollar amount for requested quarantine facilities for Albany, CA nor the FY 84 increase for Reno, NV

C. Major Accomplishments by ARS Scientist in Pasture and Rangeland Weed Research

New direct planting methods without tillage for establishing legumes in stubbles of silage corn and small grain - Ithaca, NY. USDA scientists at Cornell University have developed methods for planting legumes by direct planting without tillage that result in establishment successes and yields equal to or greater than those obtained by conventional tillage. By applying appropriate herbicides at the proper time after harvest of silage corn or small grain, or after killing of cover crops, and planting legumes with newly developed drills, establishment success probabilities with legumes exceeded 90%. These methods allow planting later into spring and earlier in mid- and late summer. This technology will increase crop yields, reduce tillage and energy requirements, improve water use efficiency, reduce soil erosion, reduce production costs, and increase net profits on farms.

Pastures and run out legume hay fields can be renovated by no-tillage means - Ithaca, NY. USDA researchers have developed technology for site programs involving integrated combinations of herbicides, fertilizers and planting equipment to establish birdsfoot trefoil and clovers in pastures and sods with very high success probabilities over the last five years. Because of technology developed by federal researchers at Cornell, the percentage or establishment successes for legumes in sod have nearly doubled in the last five years. The farmers now have economically feasible options for no-tillage planting of these legumes and should benefit considerably from reduced energy requirements, higher grazing capacities on pastures, lower costs, higher profits, and reduced erosion.

Alfalfa can be established in sods after solving the pest problems - Ithaca, NY. Through integrated pest management approaches USDA and Cornell researchers found that alfalfa could be established successfully in sod if the vegetation was controlled by herbicides and if a combination of molluscicide and insecticides was applied at planting. If the combination treatments can be made economically feasible, the incidence of successsful no-tillage alfalfa establishment in sod would rise dramatically.

Yellow nutsedge propagation in summer and fall is now better understood - Ithaca, NY. USDA and Cornell researchers developed a scheme for controlling yellow nutsedge in mid-summer, late summer and early fall-planted crops geared to the time of the weed emergence and the subsequent formation of reproductive tubers. Best time for control after emergence shifts with declining day length and soil temperature. Proper timing of herbicide should result in best control of nutsedge and prevention of reproductive tuber information.

Metribuzin controls goosegrass in forage bermudagrass - Tifton, GA. A post-emergence treatment of metribuzin eliminated 95% of the goosegrass, a common, troublesome weed, in a forage bermudagrass planting. This treatment increased bermudagrass coverage by 30% in the first year and can increase the value of bermudagrass hay yields by $120 to $180 per acre during the stand's first two years.

Extension of spray season with 3,6-dichloropicolinic acid - College Station, TX. Field studies indicated that 3,6-dichloropicolinic acid was not only one of the most effective herbicides on honey mesquite but that the season of application may be extended since August and September applications were as effective as May and June treatments. Other foliar applied herbicides such as 2,4,5-T and picloram are not very effective after June. This would allow treatment of 3,6-dichloropicolinic acid late in the season when drift to susceptible crops may not be a problem and when weather conditions for spraying may be more favorable.

Absorption and translocation of triclopyr - College Station, TX. Uptake and transport studies of triclopyr were completed in honey mesquite. Data indicated that about equal amounts of the ester and amine were absorbed by leaves and transported to other plant parts. Transport in phloem to the upper and lower stems was greater early in the season (May) compared to August and September. Triclopyr movement and effectiveness in honey mesquite is similar to 2,4,5-T. Triclopyr is a possible alternative to 2,4,5-T for honey mesquite control. Knowledge of timely application will provide most economical control of honey mesquite with triclopyr.

Kleingrass establishment - College Station, TX. Field data indicated that kleingrass could be successfully established even under conditions of severe drought during the growing season if annual broadleaf and grassy weeds were controlled.

Delivery system developed for aerial application of herbicide pellets - College Station, TX. A positive-feed, vaned-rotor metering system was developed to aerially apply both extruded and pressed herbicide pellets to rangeland for woody plant control. The system has been evaluated and used to successfully apply both 3.2-mm diameter extruded tebuthiuron and 1-cc hexazinone pellets to field plots.

Spray droplet size analysis - College Station, TX. A particle measurement spectrometer system was used to measure the size distribution of sprays produced by hydraulic nozzles and rotary atomizers. For hydraulic nozzles, factors that affect the degree of droplet shear by an airstream (i.e. air velocity, nozzle orientation in the airstream and spray angle) were found to have a greater influence on the production of small droplets ($<100\mu m$ diameter) than spray pressure of liquid properties. The addition of a high concentration of polymer additive to water reduced the amount of small droplet produced; however, low concentrations of polymer additive resulted in increased production of small droplets. Increasing the nozzle orifice size and reducing the cone angle reduced the percentage of spray volume composed of small droplets. In a comparison of 0 degree nozzle orientation and 45 degree nozzle orientation, hollow cone nozzles were found to produce sprays having identical volume median diameters; however, the 45 degree orientation resulted in higher percentages of spray volume in both small and large droplets than did the 0 degree orientation. Solid jet nozzles produced fewer small droplets and more large droplets than did the hollow cone nozzles. Droplet size measurements for a rotating bowl (Micromax) atomizer indicated that the volume median diameter increases as the flow rate is increased and decreases as the rotational speed is increased. Droplet size was also affected by some spray mixtures, however the relationship of droplet size to liquid physical properties has not yet been determined. The rotating atomizer was found to produce a narrower range of droplet sizes than is customarily obtained with hydraulic nozzles.

Automated spray deposit analysis system developed - College Station, TX. A method of rapid spray deposit analysis for aircraft has been designed and developed. A prototype system for field use is in the final phases of construction and preliminary testing. The system is capable of quantitative evaluation of such spray deposit parameters as: mean deposit, standard deviation, coefficient of variation, total swath width, effective swath width and percent spray recovery. The system also provides a graphical record of the swath distribution profile.

Biological control of brush - Temple, TX. The weevil Heilipus, the moth Carmenta, and the flat-headed borer Dactylozodes are under study in Argentina for control of snakeweed and the round-headed borer Megacyllene mellyi from Brazil (received via Australia) is under study at Temple for control of baccharis. Promising insects were also found in Argentina for control of whitebrush, mesquite, tarbush, and creosotebush. The role of several key native insect species in controlling snakeweed, mesquite, and bitterweed has been determined.

New grass establishment methods - Temple TX. Planting germinated grass seeds in gel produced substantial improvement in grass stand establishment as compared to planting untreated grass seeds. Transplants grown in plastic bandoleers established plants easily under harsh environmental conditions and greatly improved the probability of success in grass establishment.

Alternatives for management of common goldenweed - Temple, TX. Common goldenweed is a small shrub which severly reduces forage production, especially after larger woody brush plants are mechanically removed. Controlled burning effectively suppresses infestations for 3 years. Where infestations are too dense to allow sufficient grasses to carry a fire, complete control is consistently obtained with the pelleted herbicides picloram and tebuthiuron. Use of fire in conjunction with pelleted herbicides reduces the required rate of herbicide application by half. Applied as a foliar spray, the new herbicide triclopyr provides excellent control of common goldenweed at acceptable rates.

Picloram used in the rope wick applicator is highly effective for controlling perennial pasture weeds - Columbia, MO. Picloram is more effective than dicamba, glyphosate and 2,4-D for killing perennial pasture weeds when used in a rope wick applicator. Leaves and stems from picloram-treated weeds may kill pasture legumes in the area, but the residue was not detected the second year after application and it should be possible to establish legumes after the second year.

Herbicides for brush control evaluated - Las Cruces, NM. A number of herbicides were aerially applied to 5 ha plots 1977-79. The plots infested with honey mesquite treated with 0.5, 1.0, and 1.7 kg/ha active ingredient of tebuthiuron pellets in 1977 had plant kills of 23%, 60%, and 93%, respectively. Treatments greater than about 1.3 kg/ha of tebuthiuron severely depressed the residual stands of desirable mesa dropseed on this sandy site. It appears that 1.0 - 1.1 kg/ha of tebuthiuron would be an effective control on areas infested with honey mesquite. The plots infested with creosotebush and tarbush treated with 0.2, 0.6, and 1.3 kg/ha of tebuthiuron pellets in 1977 had plant kills of 62 and 76%, 95 and 98%, and 91 and 98% of creosotebush and tarbush, respectively. These data suggest that 0.2 - 0.3 kg/ha active ingredient of tebuthiuron pellets would be effective for controlling creosotebush and tarbush.

Response of mesquite dunelands to applications of 2,4,5-T - Las Cruces, NM. Applications of 2,4,5-T to selectively control mesquite on dunelands resulted in grass and forb production of 985, 665, and 576 kg/ha in the first three seasons following treatment, respectively. Production on a non-treated area was 343, 156, and 259 kg/ha in the three seasons, respectively. Perennial grass production was three- to eight-fold greater on the treated area than on the non-treated area. Preliminary results of studies of small mammals, birds, insects, and soil micro-organisms indicate that treatments had a minimal impact on populations.

Hydrology of arid ranges - Las Cruces, NM. Design of criteria for water ponding dikes was determined. Ponding water at a depth of 7.5 cm provides adequate water to wet a silty loam soil profile to 1.2 meters while water ponded at 15 cm wets the soil profile to a depth greater than 2.7 meters. Utilizing a diking system for ponding runoff water from an upslope barren area, native grass production was increased from 2,635 to 4,871 kg/ha. Three conclusions from infiltrometer tests on creosotebush infested rangelands were noted: 1) bare soil plots had the least infiltrations and the most runoff, 2) creosotebush plots had the greatest infiltration and the least runoff, and 3) grassed plots had greater infiltration than bare soil plots but less infiltration than creosotebush plots.

Absorption and metabolism of tebuthiuron by range plants related to selective control - Tucson, AZ. The rangeland weed shrubs wait-a-minute bush, velvet mesquite and catclaw acacia, absorb and accumulate large amounts of tebuthiuron from the soil, but the range grasses, Rothrock grama, Arizona cottontop and Lehmann lovegrass, absorb and accumulate only small amounts. The grasses breakdown tebuthiuron rapidly, but the shrubs do not. This differential in absorption and metabolism is the primary basis for selective control of these shrubs in grasslands.

More lovegrasses established in tebuthiuron-treated than in root-plowed areas - Tucson, AZ. Boer lovegrass seedlings were established in greater numbers in areas in which creosotebush, tarbush and whitethorn acacia plants were killed two years prior to planting than in areas in which the shrubs were killed with a rootplow immediately prior to planting. This finding is important because it helps to explain the poor success in establishing grasses in creosotebush communities.

Wide range of weed-feeding insects distributed to states for release - Albany, CA. In 1981 nine species of weed-feeding insects from Europe and Pakistan were shipped to a total of 16 states throughout the U.S. to combat eight species of weeds (e.g. Carduus nutans, Centaurea spp., Cirsium arvense, Euphorbia esula, Salsola, Hypericum and Silybum marianum). These and other insects continue to make inroads against the weeds, their impact varying in proportion to the environmental stresses acting upon the weed and the insects.

Economic evaluation of weed control options in western juniper woodlands - Reno, NV. Cost was compared among four alternatives for improvements on maturing western juniper (Juniperus occidentalis) woodlands. The alternatives were: 1) the use of piclorma to kill the trees with no further treatment, with a total cost of $31 per acre ($78 per ha); 2) picloram with sufficient limbing and/or removal of trees to allow passage of a rangeland drill for seeding at a cost of $179 per acre ($448 per ha); 3) mechanical clearing and burning of the trees at a cost of $237 per acre; and 4) wood harvesting and slash disposal at a cost of $832 per acre ($2,080 per ha). Based on equivalent

energy values, the wood-harvesting and slash disposal operation would produce a profit for the landowner who could afford to invest labor. For a specific woodland, a combination of chemical and nonchemical treatments would be most cost effective.

Pilot testing of weed control, seeding, and grazing management technologies on degraded sagebrush rangeland - Reno, NV. The basic treatments for weed control and seeding on rangelands were physically established at the Gund Research and Development Ranch for the pilot testing program. The large-scale, 16 hectare treatment plots were established with field scale equipment, side by side, in a common potential environment. The soils, plant and animal communities, and watershed characteristics of the study area were enumerated before the treatments were applied and are being monitored during the treatment establishment period. Actual cost data were collected and a budget was prepared for all treatments. This pilot research and development program provides an unique opportunity to comparatively evaluate integrated pest management on rangelands in terms of cost effectiveness, biological efficiency, and environmental effects.

Ecology and control of poisonous range plants - Logan, UT. Sampling of vegetation indicated cattle utilized white pointloco (*Oxytropis sericea*) during the first week in an infested pasture and had utilized in excess of 63% of the reproductive scapes by the end of the 6 week grazing period. Clipping studies indicated the cattle had utilized 41% of the annual production of the locoweed. Twelve years of data have been accumulated on the benefits of controlling barbey larkspur (*Delphinium barbeyi*) in a 2,000 acre pasture. The results indicate that losses have been 150 cows less than would have been expected had the larkspur not been controlled. The value of 150 cows is $37,500 at $250/head. Controlling the larkspur is estimated to have cost $2,050.

Isolation of nitro compounds in Lotus, classification of nitro compounds in foreign Astragalus, and isolation of saponins in Bulnesia sarmiente - Logan - UT. Nitro compounds were found in 17 species of *Lotus*. Dried plant and extracts of *Lotus pedunculatus* produced nitro poisoning in 1-week-old chicks. The isolation of toxic levels of nitro compounds will restrict the use of *L. pedunculatus* in pasture mixtures. Species of *Astragalus* examined in 19 Old World and 21 North American taxonomic sections synthesized nitro compounds that yielded 3-NPA upon hydrolysis while only 3-NPOH was found upon hydrolysis in species of 5 Old World and 10 North American taxonomic sections. These data are used to classify *Astragalus* and to prevent introduction of poisonous plants. Toxic saponins were isolated from the seeds of the palo santo tree (*Bulnesia sarmiente*) of Paraguay and an LD_{50} was established for 1-week-old chicks.

D. Recommendations for Future Research

National Research Priorities

The National Research Priorities were derived in consideration of location priorities, existing research gaps and areas needing special emphasis. They were ranked and are listed in priority order.

Priority 1. Study the biology, ecology and edaphic factors as the basis for control technology.

Priority 2. Brush and weed control on grazinglands with special emphasizes on improving desirable vegetation.

Priority 3. Absorption/translocation/metabolism of herbicides in weeds, brush and forage plants.

Priority 4. Economic assessment of weeds and brush control technology.

Priority 5. Develop improved herbicide formulations and delivery systems technology.

Priority 6. Systems technology for vegetation manipulation, management and multiple use objectives.

Priority 7. Foreign exploration and cooperation for biological control agents.

Priority 8. Evaluate multiple use strategies in biological control of weeds and brush.

Priority 9. Develop and use models to improve weed and brush technology.

Priority 10. Livestock grazing management to manipulate and manage weedy rangelands.

Policy Issue: It was also suggested that Special Strike Force Funds be made available to support high priority research when needed to accelerate and complete important technological developments.

The group also unanimously agreed more engineering technology was needed in our programs and every effort should be made to employ engineers to support ARS research and missions.

Summary of Location Research Priorities

Prior to the conference each scientist submitted a research priority list for his location (See page 28). At the conference each priority was evaluated by all conference participants by ranking them from 0 to 10 (0 having no value and 10 the highest value). The results were summarized as follows:

The priorities from locations mentioned most frequently are listed according to rank (highest to lowest).

Priority 1. Improve the efficiency and economy of weed and brush control methods for pastures and rangelands.

Priority 2. Improve weed control for forage establishment and maintenance in hay crops, pastures, and rangelands.

Priority 3. Document the biology and ecology of weeds, brush, and range plants including their establishment, growth, development, and reproductive strategies.

Priority 4. Discover, evaluate, introduce, and establish biocontrol agents for weed and brush on pastures and rangelands.

Priority 5. Determine the distribution, persistence, and dissipation of herbicides in the grassland ecosystem.

Other location priorities mentioned less frequently but received a high priority rating were as follows:

1. Intercept poisonous plants upon introduction and control poisonous weeds on grazing lands.

2. Develop integrated establishment-management systems to improve the forage value of range and pasture vegetation.

3. Analyze the economics of weed control in forage crops.

4. Improve herbicide application technology. Optimize spray droplet size to minimize drift and maximize efficacy. Develop improved herbicide pelleting technology and aerial delivery systems.

5. Investigate the physiology and biochemistry of herbicides in weeds and forages.

Individual Location Priorities (Listed as ranked by conference participants)

Ithaca, NY

1. Establishment and maintenance of forage and pasture crops in non-rotation systems by limited-tillage means with emphasis on alfalfa.

2. Interactions of herbicides and other pesticides on pest control (Integrated Pest Management) in conventional and reduced tillage systems in crop rotations involving forages.

3. Control of yellow nutsedge in forage crops: Develop management systems for control of reproductive organs by use of new herbicide technology, reduced tillage and crop rotations. The thrust is on post-crop harvest systems.

4. Control of annual and perennial weed grasses in forage crops with emphasis on the year of establishment. Emphasis will be given to reduced tillage systems.

5. Selective control of annual and perennial broadleaf weeds in forages and pastures.

6. Characterization of allelopaths interfering with forage establishment and determination of herbicide-allelopath.

Tifton, GA

1. Develop economic practices to reduce infestations of difficult to control perennial weeds in pastures. Current focus: Study the biology of horsenettle (*Solanum carolinense* L.), a serious and difficult to control perennial weed in pastures, to identify vulnerable periods or stages in its life cycle.

2. Develop establishment and weed control practices for winter annual forage legumes. Current focus: Evaluation of herbicides for use in arrowleaf and crimson clovers. Development of establishment and weed control systems for improved sweet lupine cultivars and their agronomic evaluation.

3. Improve establishment and weed control practices for high-yielding forage bermudagrass cultivars. Current focus: Experiments on preemergence, early postemergence and combination herbicide treatments for weed control in newly sprigged bermudagrasses and evaluation of herbicides for selective postemergence control of annual grasses in bermudagrass hayfields.

4. Improve weed control in summer annual forage grasses including sorghums and millets. Current focus: Developing new herbicide recommendations for sorghums and sorghum-sudan hybrids on coarse textured soils.

5. Improve control of winter annual weeds in small grains. Current focus: Evaluate herbicides for control of *Brassica* spp. in winter wheat and complex grazing mixtures which include legumes.

College Station, TX (Weed Science)

1. Evaluate new herbicides and formulations and other methods for safe and effective weed and brush control on pastures and rangelands.

2. Investigate the physiological effects and mode-of-action of herbicides on plants.

3. Investigate effects of weed and brush control treatments on establishment, production, composition, and quality of forages.

4. Determine herbicide residues in soils, plants and water sources and methods to modify residues.

College Station, TX (Engineering)

1. Optimize herbicide spray droplet size in relation to drift control, effectiveness, and cost of treatment.

2. Optimize herbicide pellet size, concentration, and application rates in relation to effectiveness and cost, and improve aircraft systems for dry herbicide application.

3. Computer-based mathematical models of vegetation control and revegetation methods.

4. Aerial application of revegetation materials.

5. On-site monitoring and detection of atmospheric conditions conducive to herbicide drift.

6. Application technology for biological control of range weeds and brush.

Temple, TX (Ecology)

1. Determine the spheres of influence of individual plants of mesquite, juniper, and pricklypear on the growth and development of associated plant species in terms of the interference production principle.

2. Determine rates and extent of woody plant invasions on rangelands in relation to cultural practices including brush control measures.

3. Characterize the time course and magnitude of essential growth processes of mesquite, juniper, and pricklypear in relation to plant growth resource extraction and utilization in key environmental settings.

4. Assess the role of leguminous shrubs (particularly mesquite) in the nitrogen relations of rangelands.

Temple, TX (Weed Science)

1. Evaluate both conventional and new weed control practices (herbicides, fire, and mechanical treatments) for use in management of perennial range weeds and undesirable shrubs.

2. Increase our understanding of the biology of range weeds through studies of their reproductive strategy and life history.

3. Describe the characteristics of epicuticular wax deposits on leaves of range weed and brush species which respond erratically to broadcast sprays, and determine how these barriers influence herbicide effectiveness.

4. Develop and evaluate a machine which directly and selectively applies herbicide solutions to range weed and brush plants.

5. Determine the fate and persistence of new herbicides after application to grasslands.

Temple, TX (Grass Establishment)

1. Find new, more reliable methods for establishing grass.

2. Develop machinery to implement new grass establishment methods.

3. (Future) Study the effect of plant spacing and plant species mixing (winter vs summer types) on forage production. Look for ways to achieve profitable spacing and plant mixing by establishment methods.

Temple, TX (Biological Control)

1. Target weeds for Texas:

   a. broomweed
   b. mesquite
   c. baccharis
   d. saltcedar
   e. loco
   f. creosotebush
   g. tarbush
   h. bitterweed
   i. whitebrush
   j. African rue

2. Research:

   a. Release, establishment, and evaluation of results
   b. Testing in quarantine in the U.S.
   c. Ecology of target weeds and their native natural enemies in the U.S.
   d. Exploration and testing overseas
   e. Evaluation of potential targets

Columbia, MO

1. Develop methods to prevent or reduce the invasion of woody and perennial herbaceous species into pastures to prevent serious infestations (spot treatments using granules, pellets or spot treatment with liquids included in wicks, rollers or other device).

2. Replacing low quality forage species and weeds with improved forage species (this has been called pasture renovation or more recently minimum till or no till).

3. Devise methods of weed control during establishment of legumes and grasses with special emphasis on controlling weeds in mixed legume-forage grasses.

4. Improve control of woody and herbaceous species in rangeland, develop methods of preventing deterioration of rangeland and develop improved methods of seeding forage species in rangeland with emphasis on warm season forage species.

Lincoln, NE (Not ranked by participants)

1. Evaluate various methods for integrated control of weeds in pastures and rangelands.

2. Evaluate insects for control of introduced weeds and role of plant inter- and intraspecific variability on effectiveness of control.

3. Investigate role of native insects on control of selected native weeds and relate biology of insects to population dynamics of the weed.

4. Develop information for better understanding of the biology of range weeds through studies of life history strategies and phenology.

5. Develop nurseries for study of phenotypic variability of major weed species to help resolve taxonomic problems.

Las Cruces, NM

1. Develop economical, environmentally acceptable techniques to manage areas infested with creosotebush, mesquite, and tarbush.

2. Develop grazing management systems based on soil-plant-animal-weather relations.

3. Determine the proper integration of native and manipulated range for the various multiple uses.

4. Determine the genetic-environmental interactions of cattle on arid rangelands by studying the effects of breeds and management systems on performance, ethology, and chemical constituents of forage, supplemental feeds, blood, liver, and milk.

Tucson, AZ (Range Weed and Brush Control)

1. Selective control of annual weeds in rangeland plantings for establishment of:

   a. grasses
   b. shrubs
   c. forbs

2. Improved methods for control of velvet and honey mesquite.

3. Cost benefit analyses of weed and brush control practices.

4. Documentation of the effects of brush control on:

   a. water infiltration and soil moisture retention
   b. ground water recharge
   c. wildlife habitat

5. Improved methods for control of catclaw acacia.

6. Research on the persistences and fate of herbicides in rangeland plants, soils, animals and water.

Tucson, AZ (Integrated Weed Management)

1. Methods of reducing initial year weed competition on range planting projects.

2. Continue research and development of efficient, safe weed and brush control methods.

3. Assess competition of weeds and brush on major range forage species - establishment, growth, stand development, etc., interactions? Do forage species affect brush and weeds?

4. Range site or habitat classification for both forage production and multiproduct used for brush species. (Grow brush species where they grow best for woody - firewood, fence posts, chipboard, etc.- and forage where brush species do poorly.)

5. Herbicide fate in the environment. Loss of long lived herbicides metabolized by resistant forage species (tebuthiuron) to remove herbicide from the soil in a reasonable time - long enough to kill resistant target species (many of which sprout 2 or 3 seasons after the plant top growth is severely damaged) but short enough to prevent mass movement off of the treated area or into shallow ground water tables, allow establishment of desired plants in 2 or 3 years after treatment.

6. Widespread increase in interest in control of gambel oak for tree or grass establishment or growth. Control of similar species - similar to desired species.

Albany, CA (Not ranked by participants)

1. Increased work (i.e. finding, testing and introduction of new organisms) on specific target weeds, many of which are unique to different range areas (states) within the region.

2. Improved method of setting weed priorities and targeting candidates for biological control.

3. Research on the production of weed control organisms to hasten their increase for release and distribution to states once cleared from quarantine.

4. Assessment of plant pathogens on native weeds and a look at the role these might play in range vegetation management.

5. Need for better and standardized evaluation techniques of natural enemy impact on weeds and impact of the environment on both.

6. Improved means of resolving economic and ecological conflicts of interest surrounding target and non-target plants.

7. Integrating biological control with management practices to enhance increase of desirable vegetation.

8. (Rome, Italy) Search for and testing of natural enemies of weeds originating in Europe, Africa and Central Asia and which are naturalized pests in the U.S. Current focus on Convolvulus arvensis (field bindweed - WR, NRC, NER, SR), Euphorbia esula (Leafy spurge - WR, NCR, NER), Centaurea diffusa (diffuse knapweed - WR), C. solstitialis (yellow starthistle - WR), and Carduus nutans (musk thistle - WR, NCR, NER).

Reno, NV

1. Develop integrated weed control/seeding technologies and grazing management systems to increase productivity and assure economic viability of sagebrush rangelands. Study and evaluate the effects of these technologies on livestock production, wildlife habitat and populations, and soil erosion, water runoff, and other watershed aspects.

2. Study biology and ecology of brush species, evaluate their control with various herbicides, measure response of understory species, and develop revegetation technologies on salt-desert rangelands of the Intermountain West.

3. Study and evaluate prescribed burning on sagebrush rangelands for brush and weed control and seedbed preparation.

4. Utilize remote sensing technology to develop optimum systems for brush and weed control and management on rangelands.

5. Study and evaluate effects of brush and weed control on big game ranges in relation to cattle and deer grazing and browsing.

Logan, UT

1. Intercept introduced poisonous plants that might be seeded on western ranges and pastures. Conduct chemotaxonomic studies on introduced poisonous plants.

2. Control of Delphinium, Lupinus, Astragalus, and other poisonous range weeds on western ranges and pastures.

3. Conduct physiological, biochemical, and ecological studies on poisonous plants.

4. Conduct studies on the effects of herbicides on the concentration of poisonous compounds in plants.

5. Study the effects of poisonous plants on laboratory animals and livestock in cooperation with animal scientists.